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Time-Varying and Dynamic Rate Design
A RAP Global Series Report

Massachusetts Grid Modernization Workgroup

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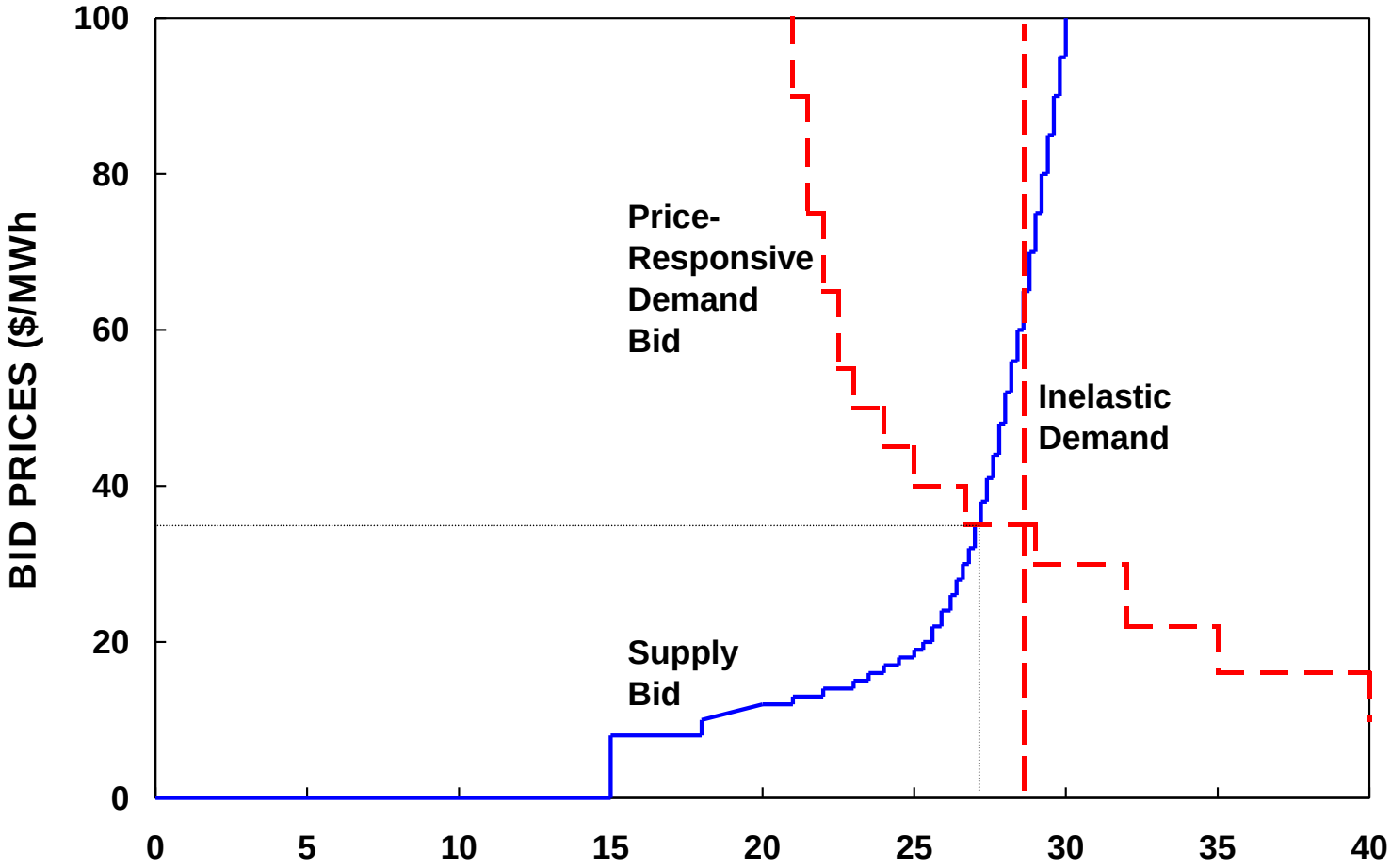
General Findings of the Report

- Metering technology is advancing rapidly
- There are potential benefits to time-varying rates, for the system as a whole and customers themselves
- Time-varying rates present risk-reward trade-offs for customers
- Key parameters must be defined when designing time-varying rates
- Well-designed pilots are critical to demonstrating the benefits of time-varying rates, and much has already been learned through pilots
- There are still some questions to be answered through additional research
- There are means for effecting smooth transitions to time-varying rate structures

Revealing the Demand Curve



The Continuum: Static to Dynamic

- Flat energy rates
  - Rates do not vary by time or wholesale market cost and include an insurance premium to protect customers from volatility (supplier bears price risk in absence of FAC)
- Tiered rates (inclining or declining blocks)
  - The cost per unit of electricity increases/decreases at defined consumption thresholds.
- Time of use (TOU) rates (time of day, seasonal)
  - Divides the period (day) into time periods and provides a schedule of rates for each period (e.g., peak, off-peak, shoulder)
- Critical peak pricing (CPP)
  - Typically an overlay on TOU pricing. During times of system stress or high cost (i.e., critical peak events), price rises to a very high level (either administratively set or market-determined) to reflect the very high but short-term cost of generating or purchasing electricity at times of shortage or peak demand. Customers are notified in advance of a CP event and the number of events per year is typically capped.
- Peak-time rebate (PTR, also critical peak rebate or CPR)
  - Participants are paid for load reductions (relative to what they would have otherwise used) during critical peak events
- Real-time pricing (RTP) rates
  - Prices may change as often as hourly. Price signal is provided to the user in advance (or at the beginning) of the period to which it applies, and it reflects the actual time- and circumstance-dependent cost of generating or purchasing electricity
  - Variable peak pricing (VPP) is a combination of TOU and RTP, wherein periods and the off-peak price are set, but the peak period price varies with the (day-ahead) market

Potential Benefits of Time-Varying Rates

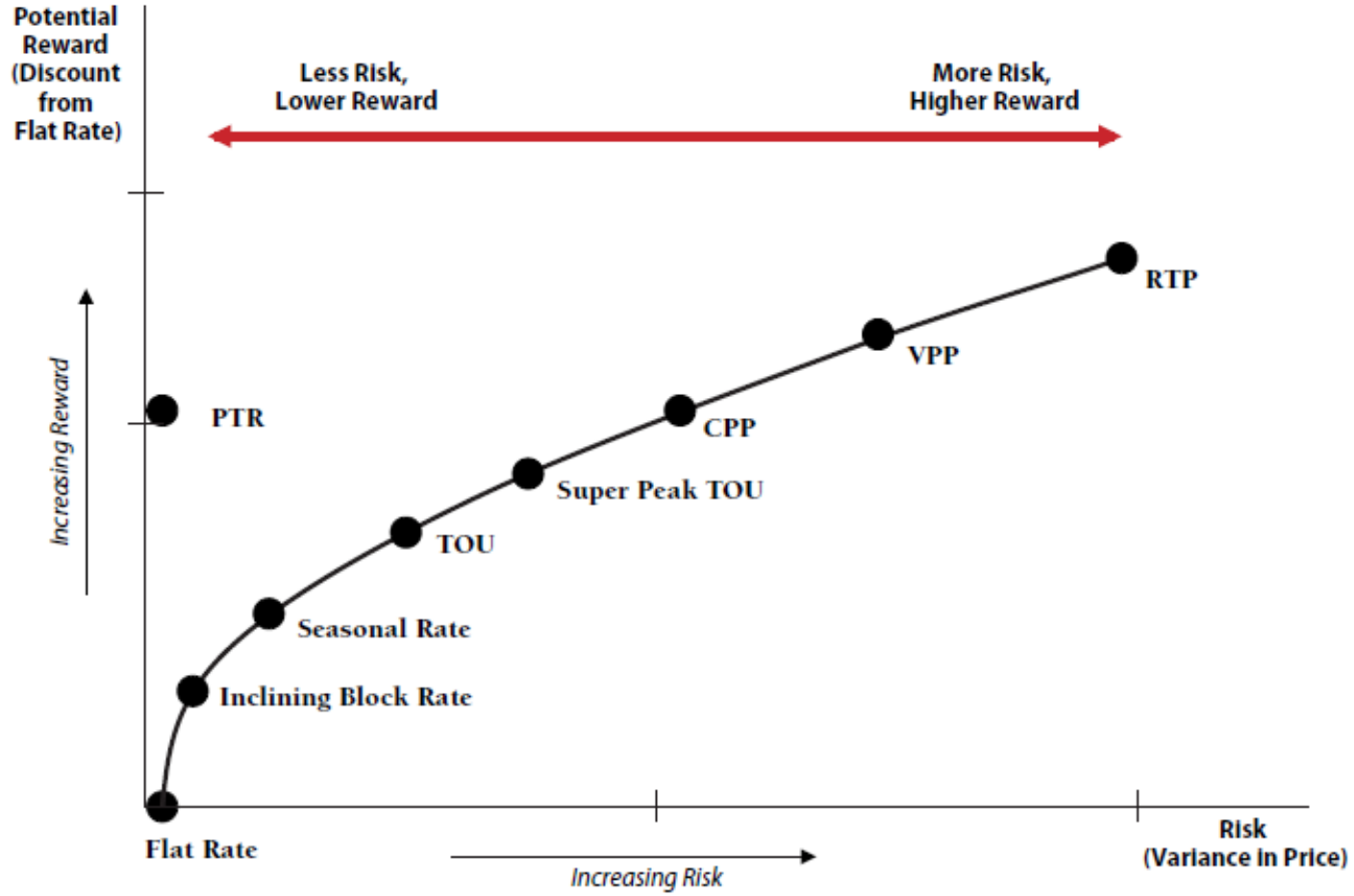
- TOU
  - Advantages: They encourage permanent load-shifting away from, or reductions to on-peak consumption. Simple, easily understood. Do not require AMI.
  - Disadvantages: Static. Don't assist in dealing with real-time events. Do not provide RE integration value.
- CPP
  - Advantages: Simple. It provides a strong price signal. Customers see high prices in only a small number of hours
  - Disadvantages: Customer and political resistance to very high prices. Utility revenue collection concerns.

Potential Benefits of Time-Varying Rates

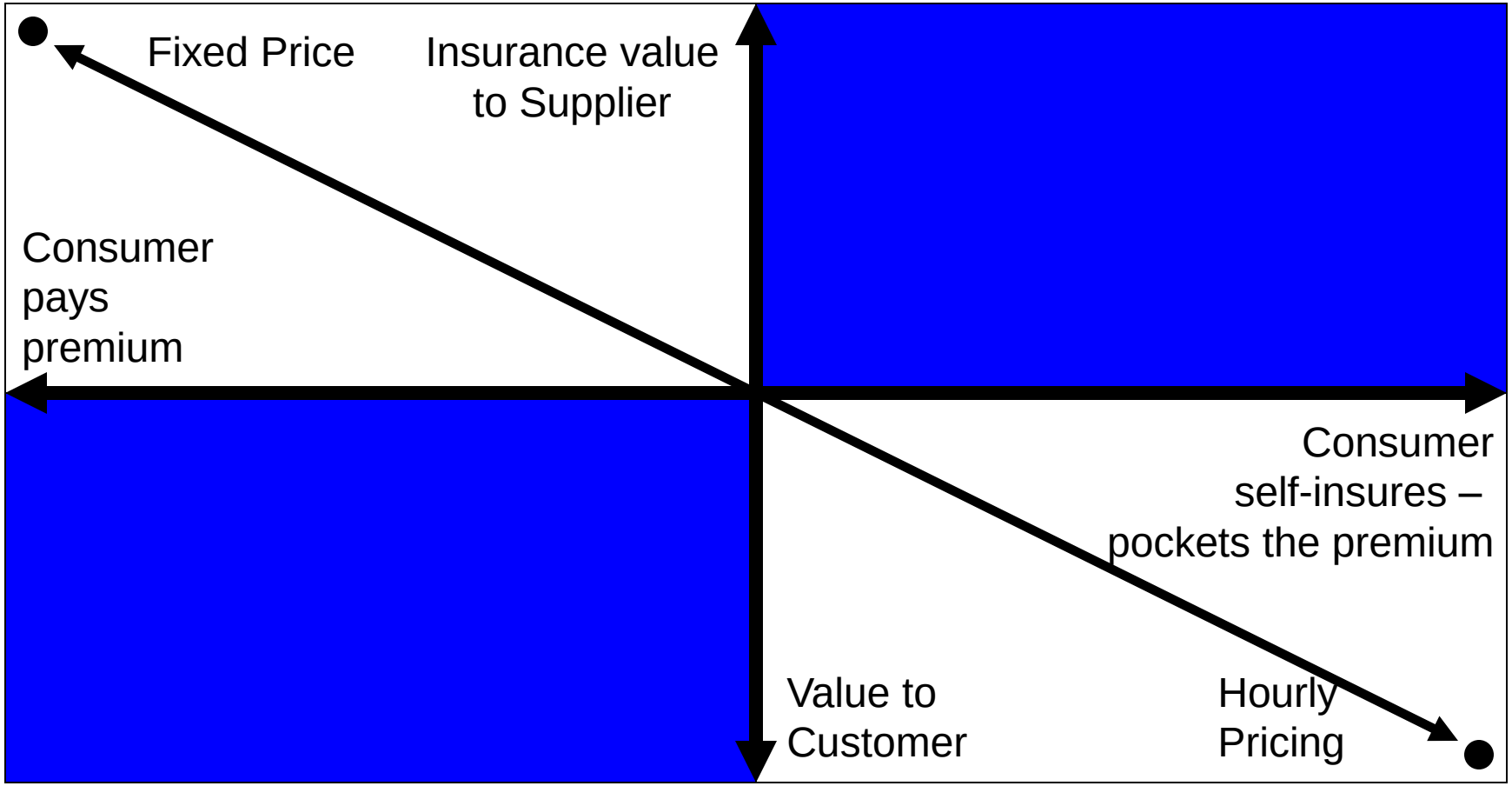
- PTR
  - Advantages: Customer bill protection—bill can only fall, not rise (in short run). Easy to understand. Signals peak costs.
  - Disadvantages: Calculation of customer baselines. Potential over- and underpayments. Mutes value of off-peak usage.
- RTP
  - Advantages: Communicates most accurate price signals (absent internalized externalities).
  - Disadvantages: Without enabling technology, it is difficult for customers to respond to hourly prices.

Risk-Reward Trade-Off

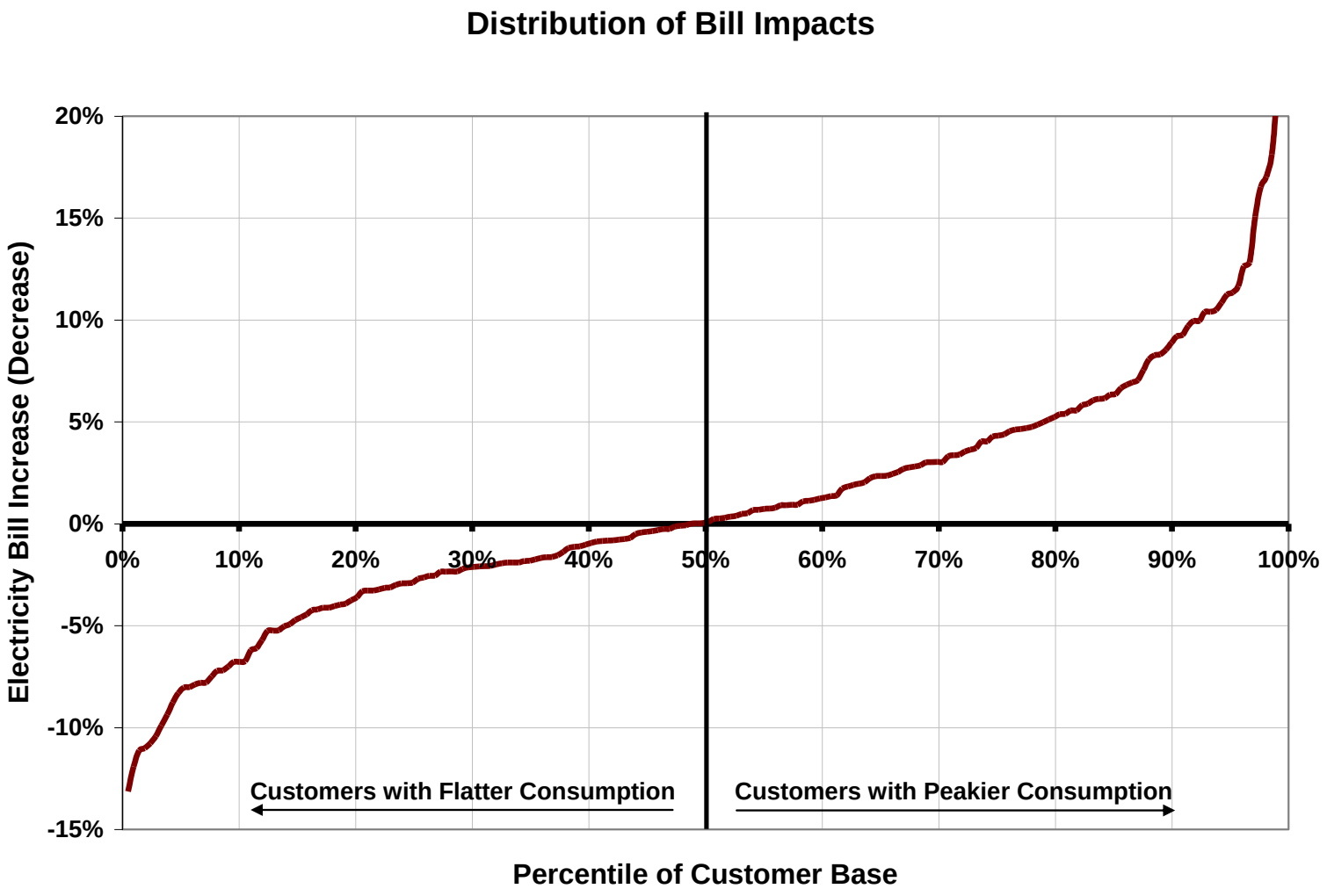
Conceptual Representation of the Risk-Reward Tradeoff in Time-Varying Rates



Who gets the insurance premium?

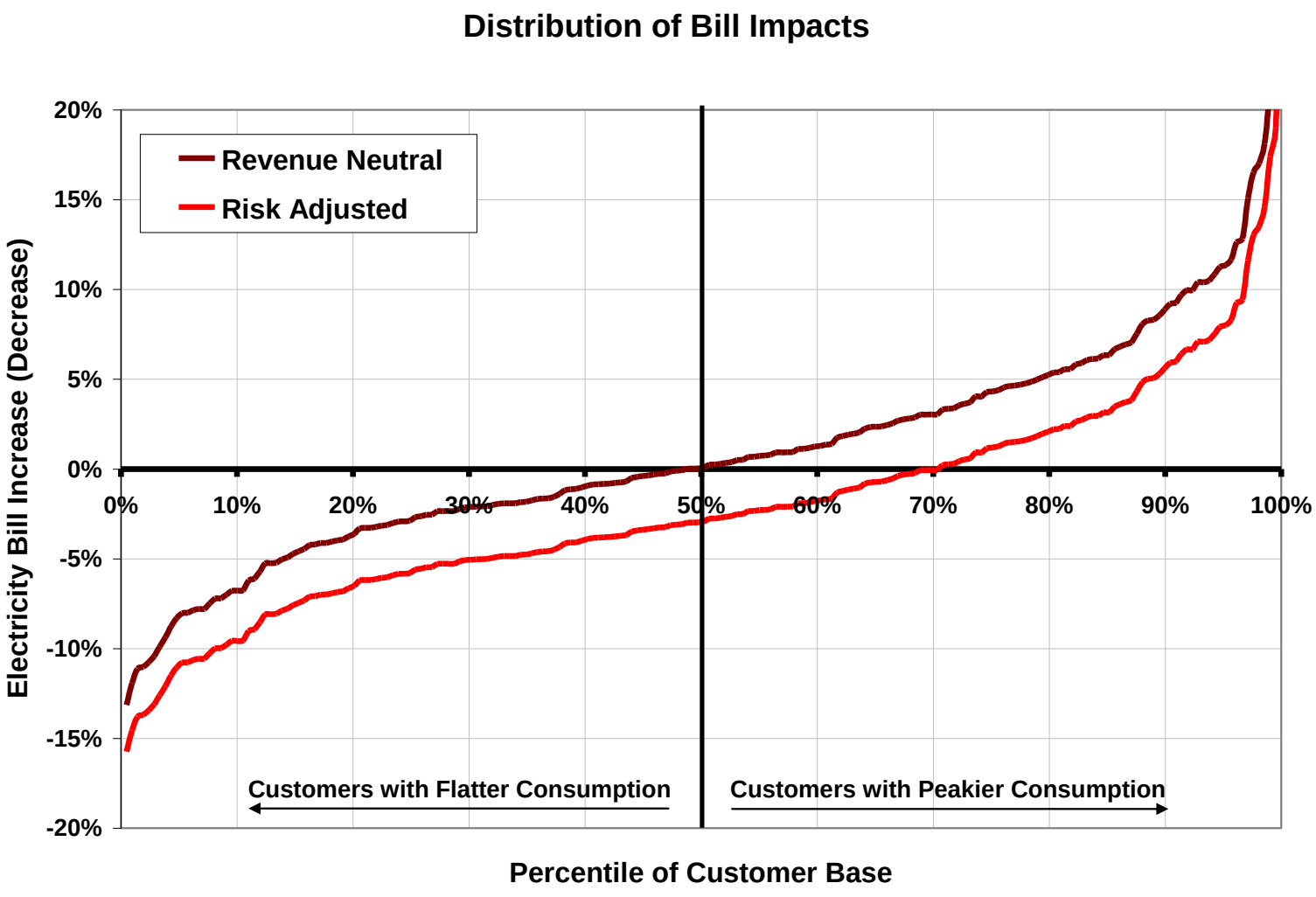


With no response, bills will rise for 50% of the customers on dynamic pricing



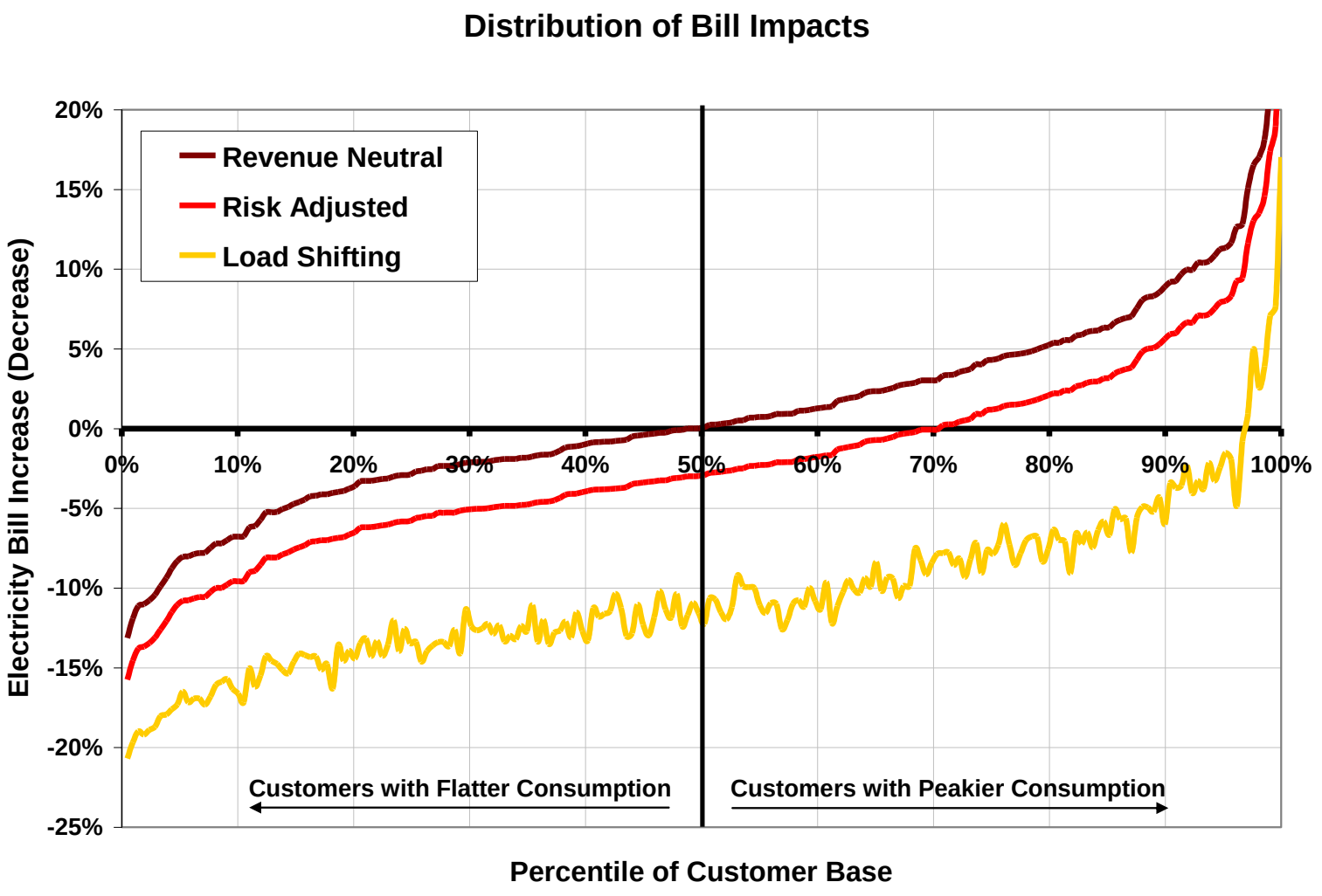
Adapted from Ahmad Faruqui, The Brattle Group

By crediting customers for the risk premium, dynamic pricing rates become attractive for 70% of customers



Adapted from Ahmad Faruqui, The Brattle Group

With demand response, dynamic pricing becomes attractive to over 95% of customers



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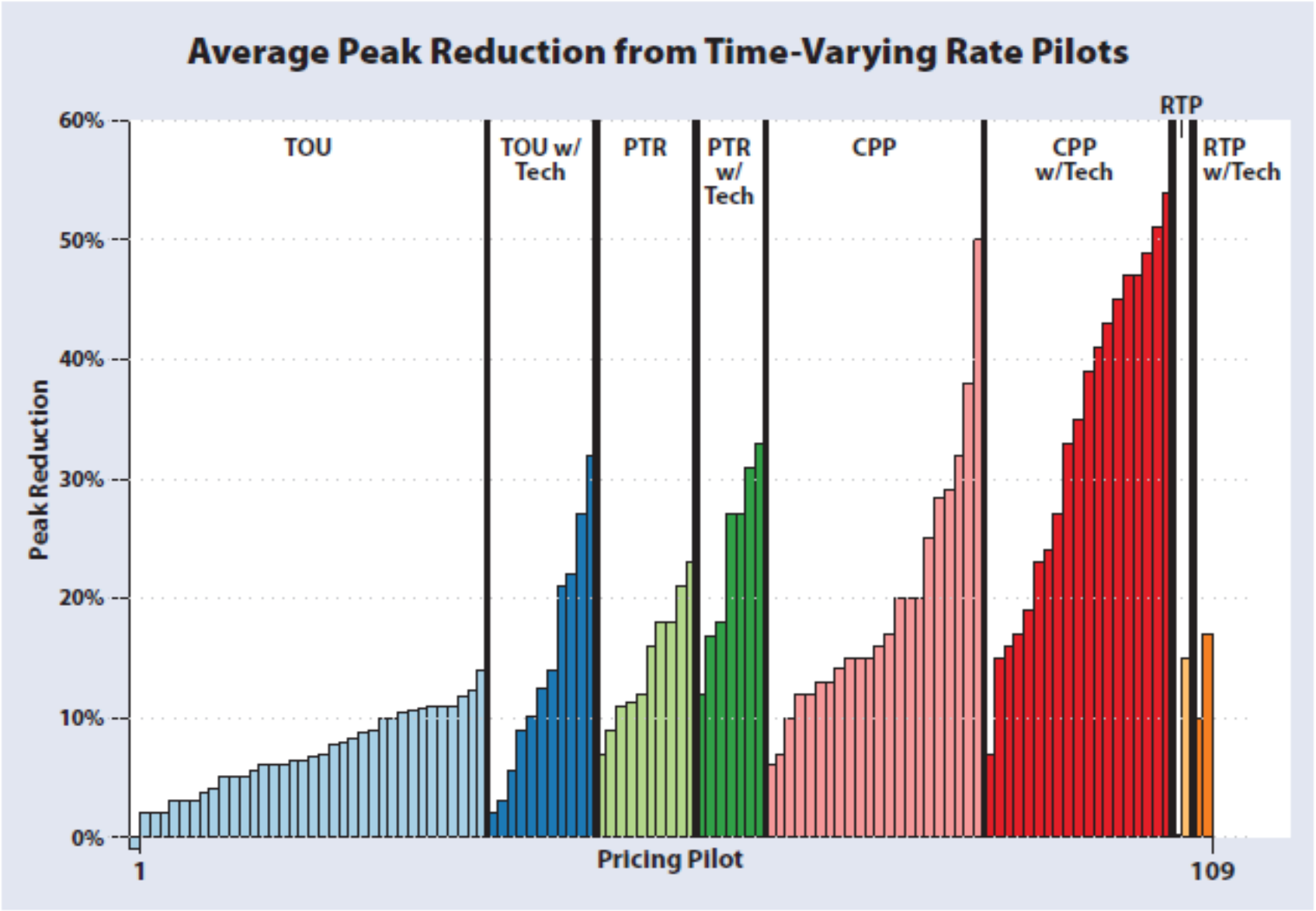
Time-Varying Rate Design Criteria

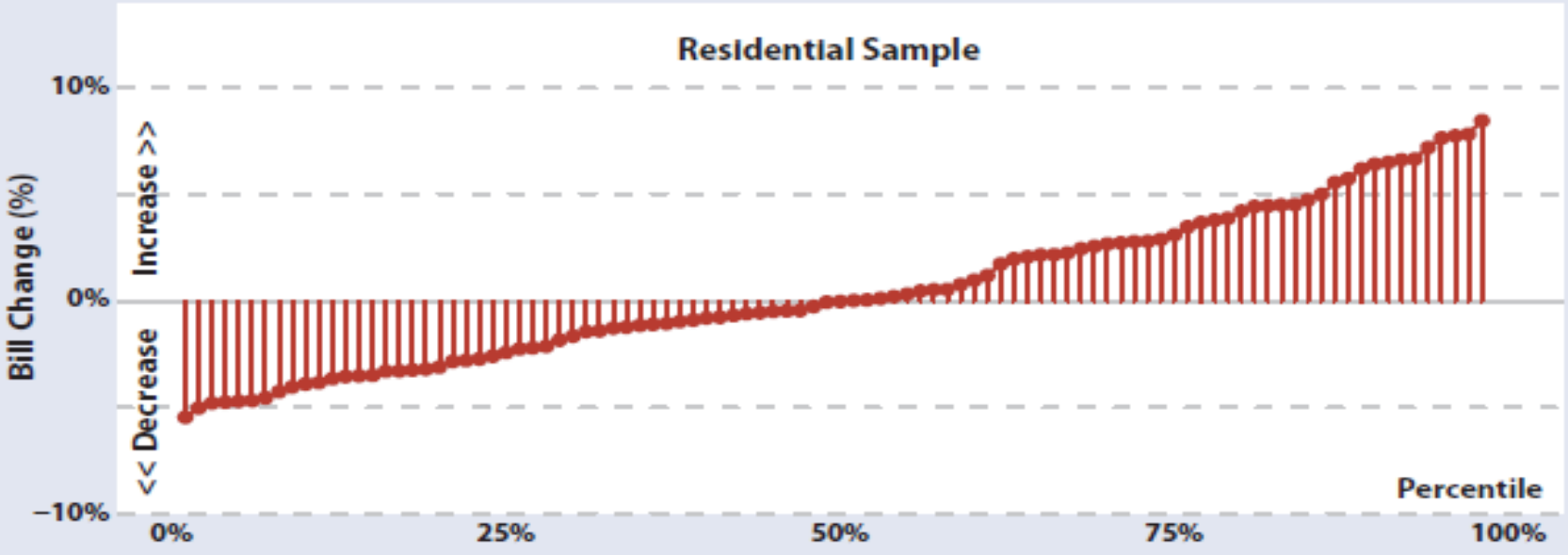
- Short peak period
- Strong price signal and opportunity for significant savings
- Rates should reflect system costs
- Simplicity is important
- Rates should account for the “hedging” premium

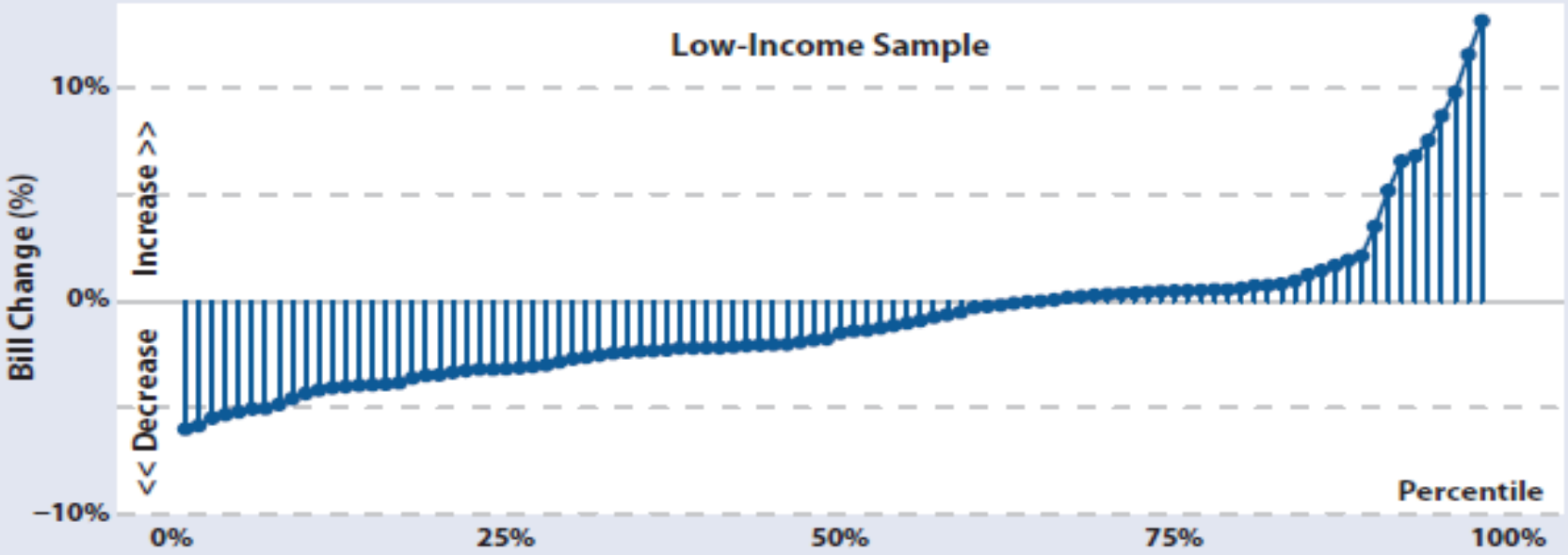

Average Peak Reduction from Time-Varying Rate Pilots
60%
50%
40%
30%
20%
10%
0%
Peak Reduction
TOU
TOU w/ Tech
PTR
PTR w/ Tech
CPP
CPP w/Tech
RTP
RTP w/Tech
1
Pricing Pilot
109

Lessons Learned from Pilots

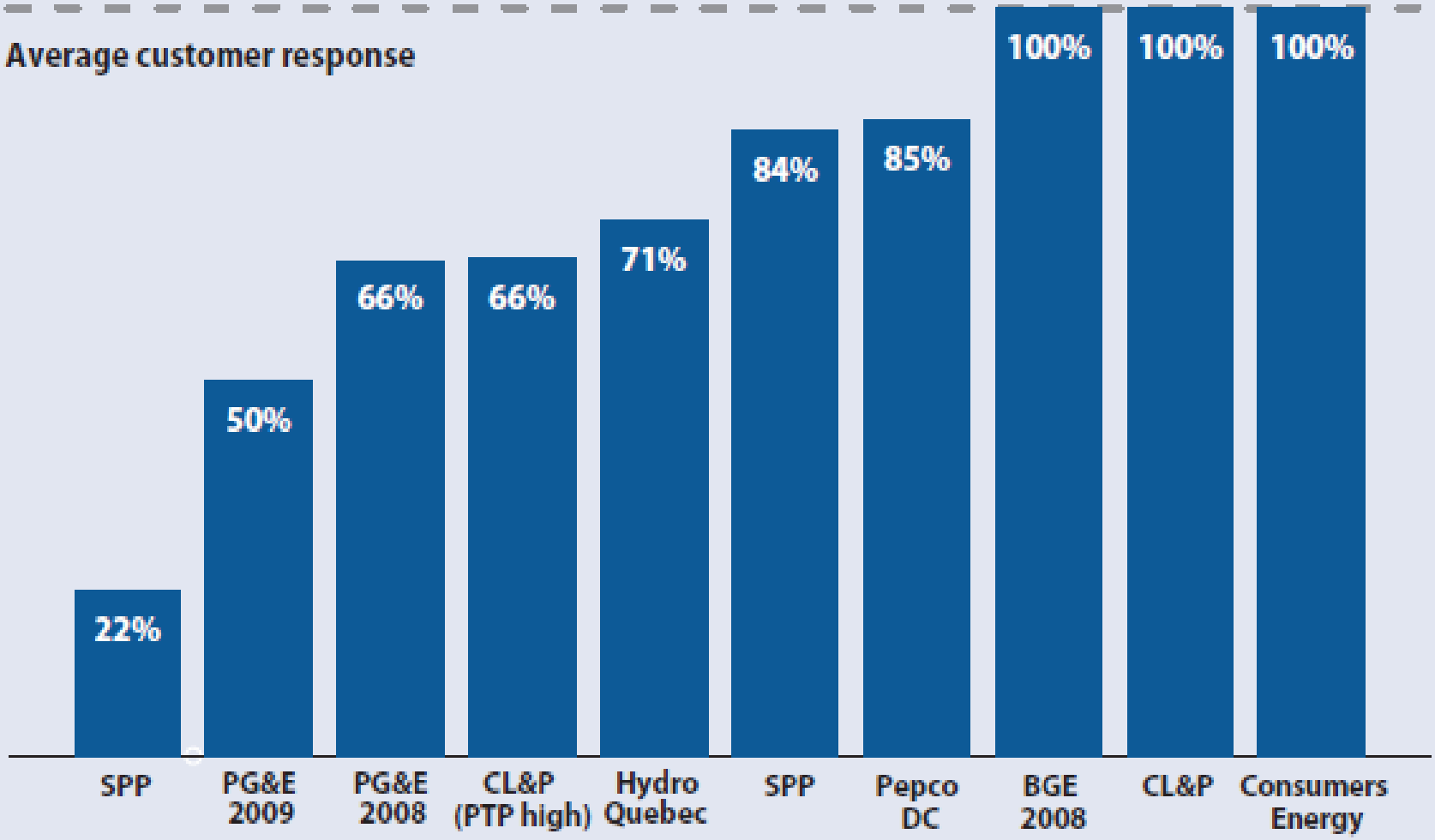
- Impacts on low-income customers
  - LI customers can respond to price signals, although not necessarily to the degree that others can
  - Data show that, even without response, more than half of LI customers benefit from time-varying prices (65% under CPP)
    - LI tend to have flatter load profiles than the average residential customer

Distribution of Bill Impacts When Moving From Flat Rate to CPP Rate





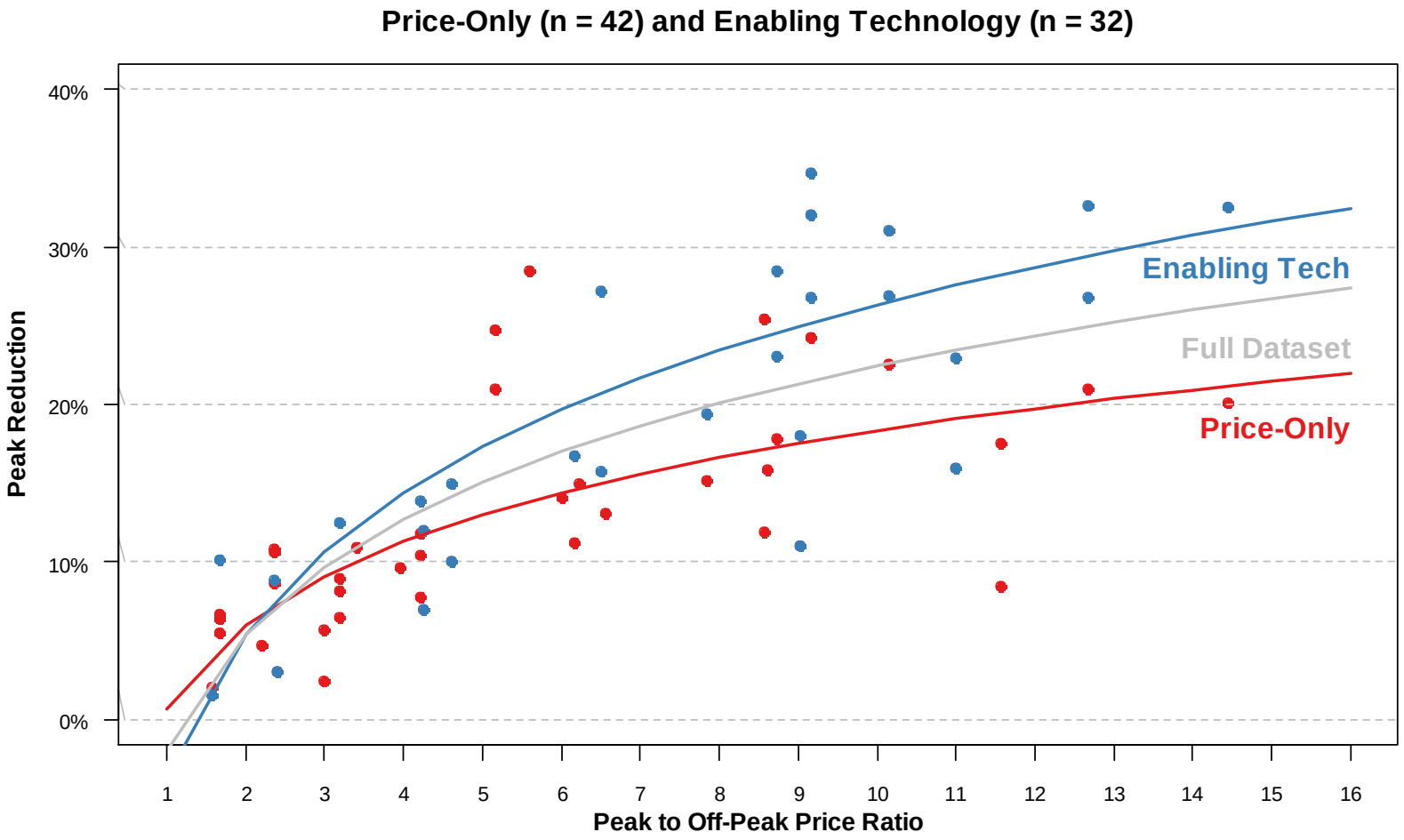
Low-income Price Response Relative to Average Customer



Lessons Learned from Pilots

- Persistence of Impacts
  - Peak savings in BGE pilot persisted for four years
  - Similar persistence for PG&E and ComEd (Illinois)
- Enabling technology shown to enhance beneficial impacts of time-varying rates

Peak Reductions with or without Enabling Technology



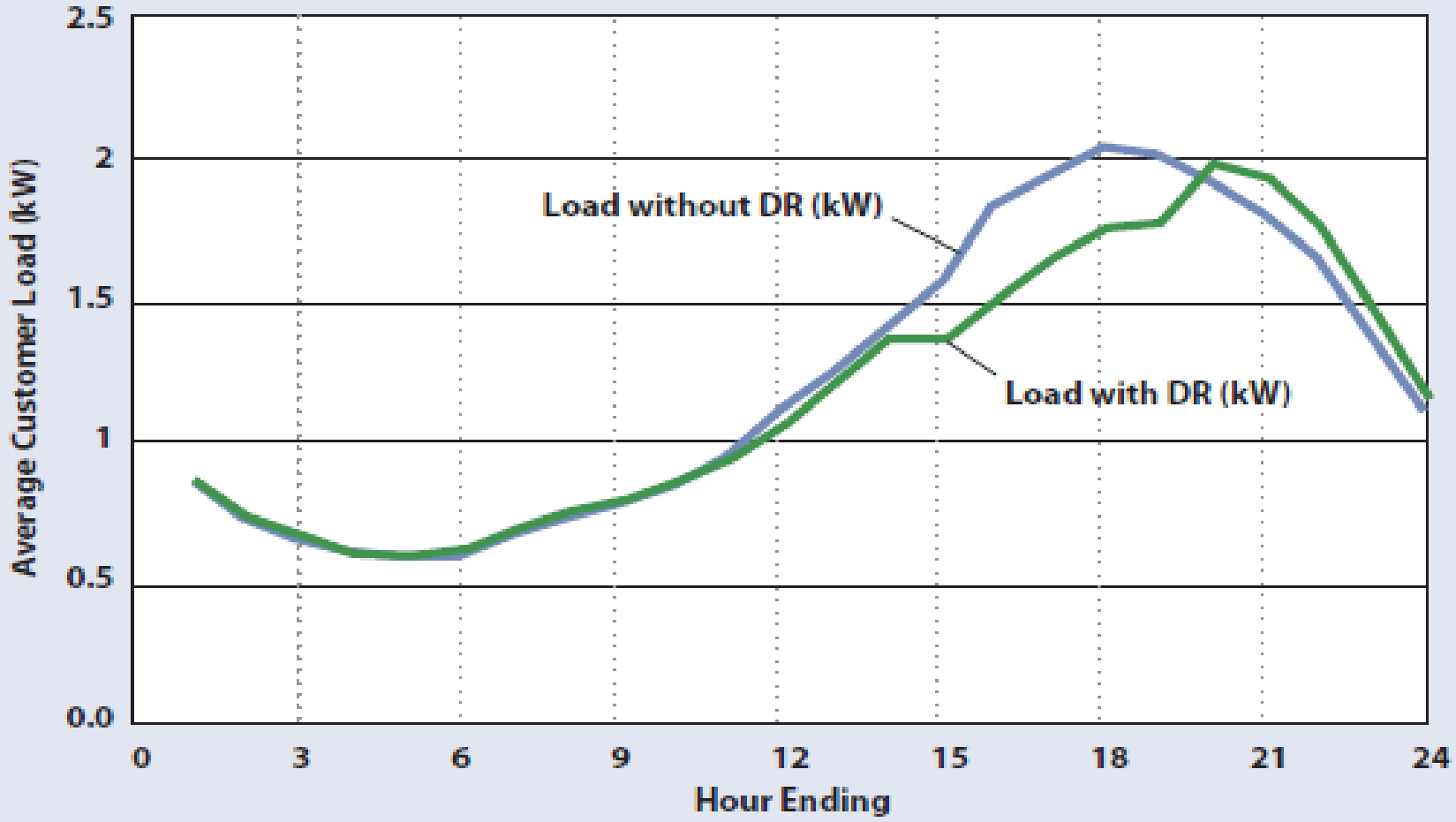
Questions Still to be Answered

- Customer rate preferences
  - In absence of mass deployments, preferences and willingness to opt out (or opt in) are not well understood
- Impact of CPP versus PTR
- Conservation impacts of time-varying rates
- Fuel-switching impacts
- Impacts of information on peak demand
  - Does, and if so how does, more (non-price) information about one's demand as it relates to system peak demand affect behavior?

Full Deployment Case Studies

- Arizona
  - Over two decades, Arizona Public Service has enrolled 51% of its customers on a voluntary TOU rate and the Salt River Project has enrolled about 30% of its customers on a voluntary TOU rate
  - In both cases, the large consumers avoid the upper tier of an inclining block rate by going with TOU
- California
  - PG&E has enrolled 80,000 customers on CPP
    - Opt-in, summer CPP program, CP price $0.60/kWh, maximum of 15 events/summer, overlaid on inclining block tariff, peak/off-peak ratios from 4:1 to 11:1
    - 2010: 13 CP events; avg. peak reduction of 14% or 6 MW; no discernible change in energy consumption; avg. bill reduction $53 (8%) for 88% of customers (inc. LI, when normalized for absence of central AC)
  - SDG&E offers PTR on an opt-out basis to 2 mn customers
  - SCE offers PTR on an opt-in basis and more than 2 mn customers have signed on

California


Average Customer Load with and without CPP on Event Days
Average Customer Load (kW)
2.5
2
1.5
1
0.5
0.0
Load without DR (kW)
Load with DR (kW)
0
3
6
9
12
15
18
21
24
Hour Ending

Full Deployment Case Studies

- Illinois
  - Both the investor-owned utilities, ComEd and Ameren, have enrolled about 25,000 customers on RTP in Illinois
  - A new state law calls for opt-in PTR to be offered statewide
- Mid-Atlantic Region
  - BGE and PHI will be offering PTR to 2 million customers over the next few years in Delaware, Maryland, and DC
  - PJM is allowing price-responsive demand to be bid into its multi-state markets, as AMI and dynamic pricing are rolled out to the 51 million customers in the PJM region
- Oklahoma
  - OG&E has begun rolling out VPP and aims to sign up 20% of its customers over the next 3 years
  - Stated objective: to achieve price-induced demand reductions to avoid a medium-sized power plant

International

- Australia
  - Federal government support for a national rollout of smart meters
    - The energy minister has spoken favorably about dynamic pricing
  - A three-tier approach is being proposed by the Australia Energy Market Commission for dynamic pricing applied to transmission and distribution rates
    - Mandatory for customers that use twice as much as the average residential customer
    - Opt-in for low-income and other vulnerable customers
    - Opt-out for everyone else

International

- Canada (Ontario)
  - 4.2 million (90%) residential and small business customers are on TOU rates under a regulated retail pricing plan (October 2012)
  - All customers have the option of switching over to retail providers
  - Significant consumer education
  - Recent survey by Smart Grid Canada found that 72% of people in Ontario said they had changed their behavior because of TOU
- China
  - Beijing: 62% of customers on TOU rates by the end of 2003
  - Hebei: 40,000 customers (about half of all sales) are on TOU rates. Additionally, Hebei has instituted a mild CPP rate
  - Jiangsu: Voluntary residential TOU since 2003
  - Shanghai: TOU rate with a 4.5-to-1 peak to off-peak price ratio
  - National policy in favor of inclining block rates for residential

International

- France
  - Électricité de France has offered residential customers the "Tempo Tariff" since 1996: opt-in, variable winter TOU/CPP program in which one of three price schedules is applied each day, day-ahead notification
  - 400,000 customers enrolled
  - Total peak reduction 450 MW; avg. 10% bill reductions
- Great Britain
  - Consumer Focus found ~75% of consumers on TOU tariff are satisfied
  - Most popular TOU tariff is the Economy 7 tariff, where consumers are charged a lower price for seven consecutive hours overnight

International

- Ireland
  - The Commission for Energy Regulation is currently assessing the pros and cons of mandating TOU tariffs and intends to publish its findings by the end of this year
  - Stakeholder engagement will follow in 2013
- Italy
  - Currently, 28.8 million customers are on a TOU program
  - 18.8 million are residential customers
  - ~91% of these residential customers have defaulted to the TOU tariff

Blueprint for Time-Varying Rates

- Understand effects of current rates
- Develop consistent and comprehensive objectives for rates
- Identify menu of rate options
- Perform preliminary assessment of impacts of various rate structures
- Conduct preliminary market research
- Conduct pilots
- Deploy

Mandatory, Opt Out, Opt In

- Mandatory – Default rate, no opt-out
  - Likely to achieve the largest overall economic benefits, but potential for windfall gains or losses and customer opposition
- Voluntary – Default rate with opt-out
  - Nudges people onto more efficient rate structure
  - Preserves customer choice
  - Reduces marketing and recruitment costs
  - Creates larger potential market to enable smart appliances, energy management options and competitive pricing
- Voluntary – Opt-in recruitment
  - Least likely to provoke customer opposition, but will produce lowest participation rates and be more costly

Opt-In or Opt-Out?

- Opt-in
  - Makes sense but only if the dynamic pricing rate is net of the hedging premium in flat rates and if dynamic pricing rates are simple and easy for customers to understand
  - The rates should offer customers significant savings potential and also be offered in a way that appeals to other customer desires besides just saving money
- Opt-out
  - Better to offer it with full bill protection for the first year, which is then phased out over the next two or three years
  - One alternative is to offer two-part rates, wherein a pre-determined amount of power is purchased each period (month) at a fixed price and any additional purchases are made at the time-varying rate
  - Another is to offer peak-time rebates

About RAP

The Regulatory Assistance Project (RAP) is a global, non-profit team of experts that focuses on the long-term economic and environmental sustainability of the power and natural gas sectors. RAP has deep expertise in regulatory and market policies that:

- Promote economic efficiency
- Protect the environment
- Ensure system reliability
- Allocate system benefits fairly among all consumers

Learn more about RAP at www.raponline.org

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